Salt in Diabetes: Is there a problem?

분당서울대병원
박영미

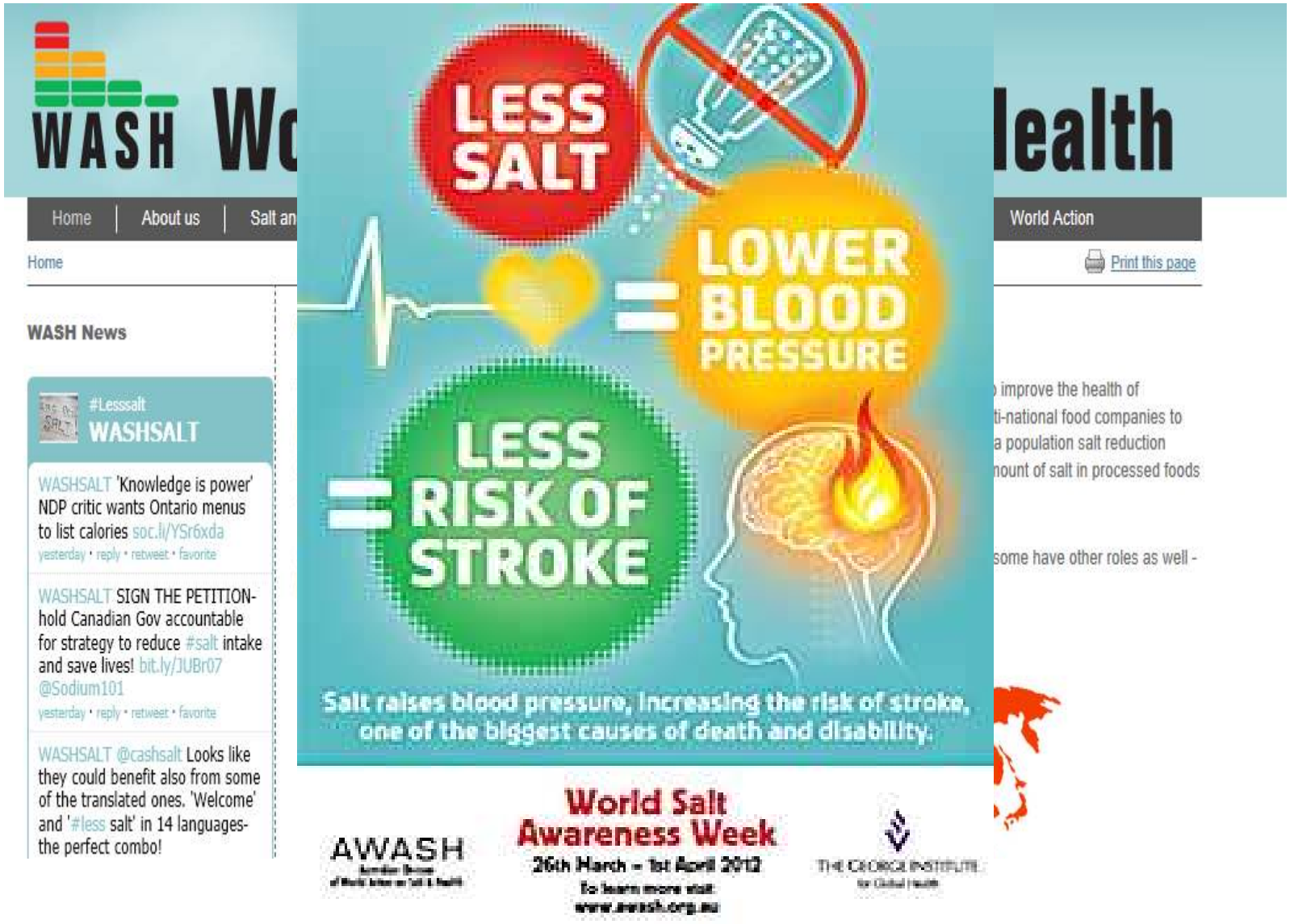
INDEX

Worldwide salt reduction program

The United Kingdom - CASH

Worldwide salt reduction program

World Action on Salt & Health (WASH)



국내 - 나트륨줄이기 운동본부

나트륨 과잉 섭취하면 무엇이 문제인가요?

과다한 나트륨 섭취가 초래하는 질병

*나트륨 과잉섭취와 질환과의 상관성 — WHO NUGAG 회의(2011, 03)

분 류	질 병
높음	혈압(고혈압), 뇌졸중, 관상동맥질환, 심혈관질환
중간	신장질환/신부전, 위암, 골다공증/골감소증/골질
낮음	당뇨, 과체중/비만, 천식, 백내장

나트륨 섭취량 얼마나 되나요?

나트륨!!

하루에 얼마나 섭취하고 있을까?

WHO 및 우리나라
최대 섭취 권고량
➡ 2,000mg

우리국민 1인당 하루 나트륨 섭취량
➡ 4,878mg(2010)

*나트륨 섭취량 증가

2007년		2008년		2009년		2010년
4,388mg	➡	4,553mg	➡	4,646mg	➡	4,878mg

*나트륨 섭취량 제외국 비교

일본	4,290mg(2009)	영국	3,440mg(2008)	미국	3,436mg(2006)

각국의 소금 섭취량

Table 1

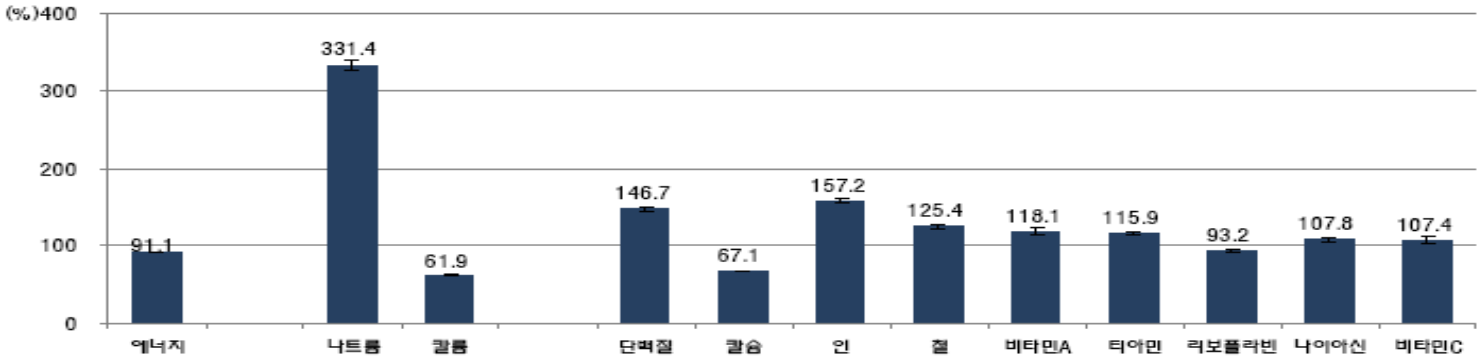
Country	Baseline salt intake (g per person per day)
Hungary	16 – 18
Barbados	12 – 15.0
Japan	13.2
Chile	10
South Africa	8 – 10
UK	9.5
USA	8.6
Australia	6.5 – 12.0

(Source: Brinsden and Farrand, 2012)

국내 소금 섭취 현황

2009

그림 12. 영양섭취기준에 대한 섭취비율

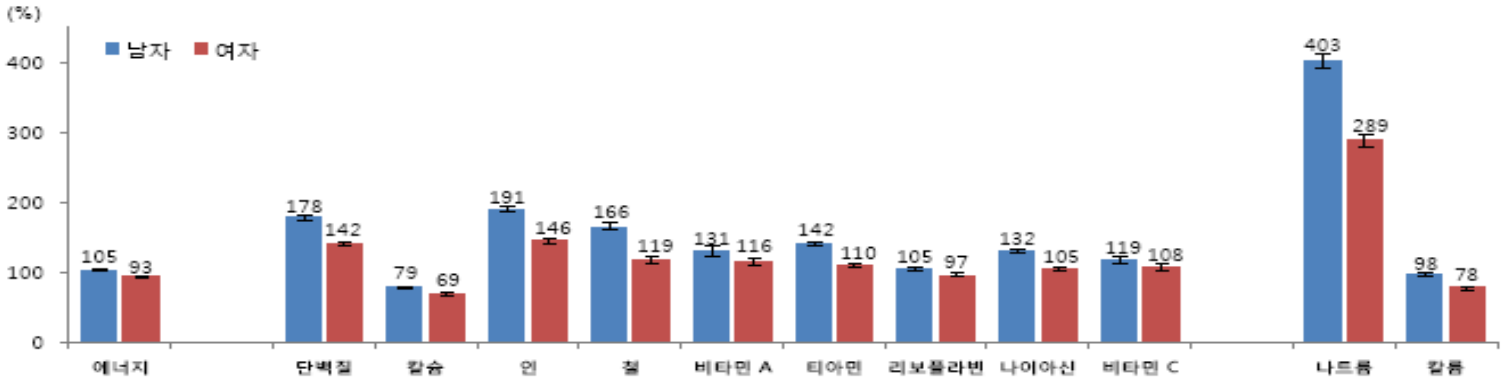


※영양섭취기준에 대한 섭취비율 : 영양섭취기준에 대한 개인별 영양소 섭취량 백분율의 평균값, 만1세이상
※영양섭취기준 : 한국인 영양섭취기준(한국영양학회, 2005); 에너지, 필요추정량; 나트륨, 칼륨, 충분섭취량; 기타, 권장섭취량

2010

4,878mg

그림 2-7. 영양섭취기준에 대한 섭취비율



※영양섭취기준에 대한 섭취비율 : 영양섭취기준에 대한 개인별 영양소 섭취량 백분율의 평균값, 만1세이상
※영양섭취기준 : 2010 한국인 영양섭취기준 개정판(한국영양학회, 2010); 에너지, 필요추정량; 나트륨, 칼륨, 충분섭취량; 기타, 권장섭취량

KNHANES, 2010

국내 소금 섭취량 조사연구 - 정상성인

저자	대상집단	조사방법	추정된 하루 소금 섭취량(g)
김기순 등 1980	30세이상 남녀성인 25명	가구당 주요 Na 공급식품 소비량 측정 → 성인치 환산	13.3g
김기순 등 1980	30세이상 남녀성인 25명	24hr UNa	16.2g
박태선 · 이기열 1985	대학생 285명	간이법 식이조사	12.8g
김영선 · 백희영 1987	20대 여대생 30명	식품수거분석	9.8g
김경순 · 백희영 1992	성인여성 62명	24hr UNa	14.8g
박은영 등 2000	남녀성인	FFQ	13.0g
손숙미 · 허귀엽 2001	40대 남녀성인 81명	FFQ	18g

국내 소금 섭취량 조사연구 – 고혈압

저자	대상집단	조사방법	추정된 하루 소금 섭취량(g)
김기순 등 1980	남녀성인 25명	가구당 주요 Na 공급식품 소비량 측정 → 성인치 환산	15.3g
김기순 등 1980	남녀성인 25명	24hr UNa	16.2g
손숙미·허귀엽 2001	남녀성인 101명	FFQ	20g
이상은 2002	65세 이상 남녀 53명	FFQ	11.8g

Korean J Community Nutr 7(3):381-390, 2002

국내 소금 섭취량 조사연구 – 당뇨병

저자	대상집단	조사방법	추정된 하루 소금 섭취량(g)
허계영 등 1998	당뇨병환자 87명	24hr UNa	남자 16.6g, 여자 12.9g
이상은 2002	65세 이상 당뇨병환자 50명	FFQ	15.6g
임현정 등 2008	65세 이상 당뇨병 환자 40명	3-day recall	남자 12g, 여자 8.8g
우지희 2010	당뇨병환자 111명	24hr recall	13g
안희정 등 2010	당뇨병환자 510명	24hr recall	14g

▷ 1980년대 10-16g, 1990-2000년 11-18g
▷ 소금 섭취량은 추정방법에 따라 다름 : 식품수거분석<24hr recall<FFQ
▷ 24hr U_{Na} 12-16g

한국인의 소금 섭취 급원 음식 및 섭취 양상

- 2008-2009 국민건강영양조사 자료에 근거
- 한국보건산업진흥원 영양정책지원팀, 식품의약품안정청 영양정책과

Table 2. Mean sodium intake of subjects by gender and age

	Total		Male		Female		t value
	Mean (mg)	SE	Mean (mg)	SE	Mean (mg)	SE	
Total	4,600	32	5,381	47	3,813	32	36.03*
1 – 2 years	1,283	37	1,292	59	1,274	53	0.25
3 – 5 years	2,017	52	2,066	64	1,956	69	1.33
6 – 11 years	3,134	52	3,393	68	2,854	66	6.97*
12 – 18 years	4,110	63	4,590	87	3,558	85	9.23*
19 – 29 years	4,854	101	5,708	155	3,943	98	11.56*
30 – 49 years	5,406	54	6,347	81	4,423	51	23.39*
50~64 years	4,987	71	5,914	103	4,071	78	17.70*
≥ 65 years	4,327	94	4,566	101	3,154	60	14.99*

*: $p < 0.0001$

소금 섭취에 기여하는 음식군

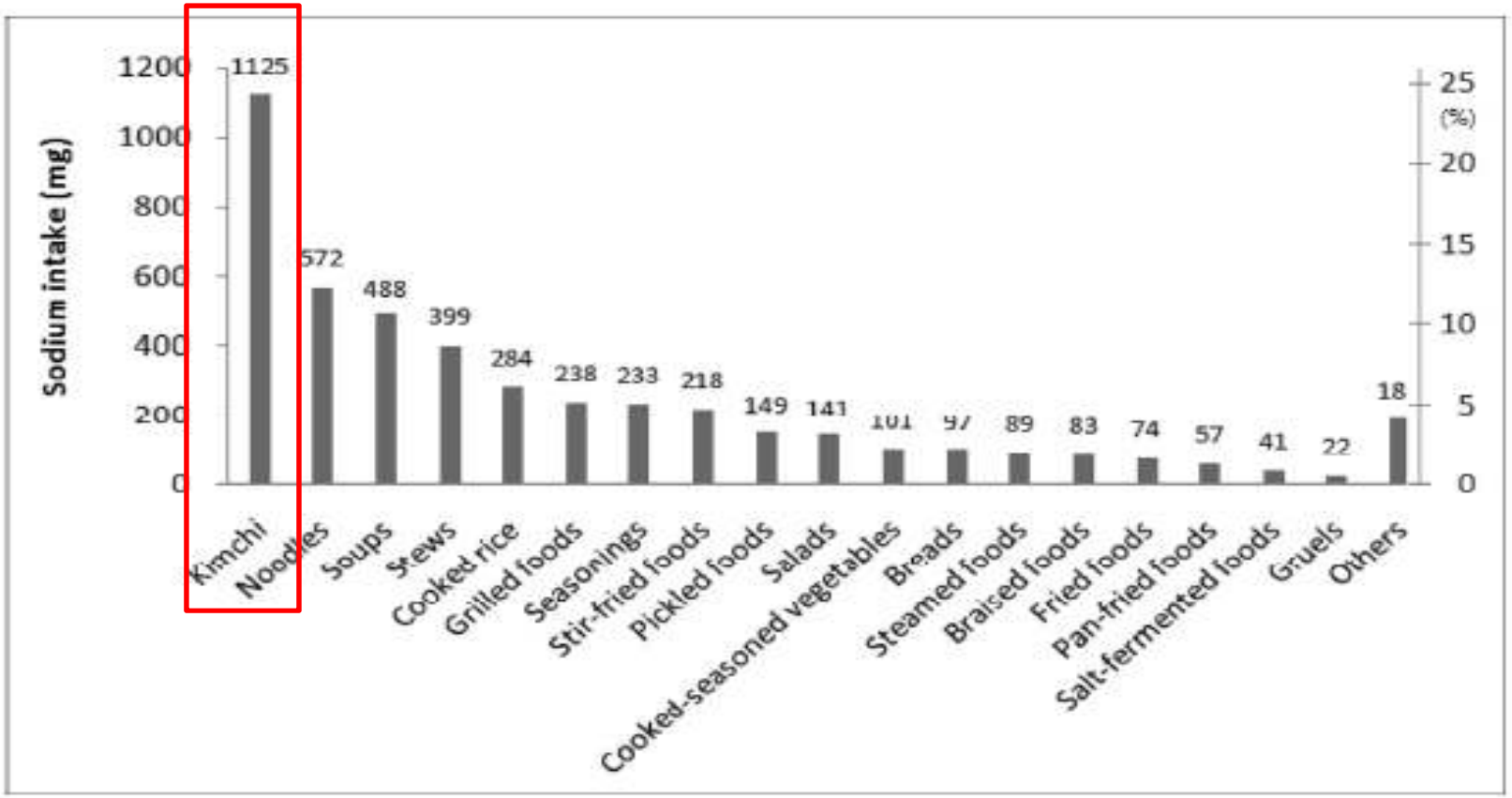


Fig. 1. Mean sodium intake and contribution to total sodium intake by individual dish group.

성별, 연령층별, 음식군 별 소금섭취 기여 비율

Table 3. Comparison of sodium intake contribution from individual dish group by sex and age of subjects

Dish group	Sex		t value	Age								F value
	Male	Female		1 – 2 years	3 –5 years	6 –11 years	12 –18 years	19 –29 years	30 –49 years	50 –64 years	≥ 65 years	
Cooked rice	7.3 [1)]	7.4	–0.12	9.0^{ab}	9.9^{a}	9.7^{a}	8.5^{b}	8.3^{b}	6.7^{c}	5.9^{c}	6.8^{c}	32.33*
Breads	2.5	3.1	–5.26*	5.6^{b}	5.7^{b}	5.1^{b}	6.5^{a}	4.3^{c}	1.9^{d}	0.9^{e}	0.5^{e}	164.57*
Noodles	11.3	9.7	5.43*	6.9^{cd}	7.0^{cd}	10.3^{b}	13.7^{a}	13.0^{a}	11.2^{b}	8.5^{c}	6.5^{d}	35.21*
Gruels	0.6	0.8	–3.19	2.5^{a}	1.5^{b}	0.7^{c}	0.8^{c}	0.4^{c}	0.5^{c}	0.6^{c}	0.8^{c}	11.37*
Soups	11.2	11.4	–0.94	15.0^{a}	15.2^{a}	12.3^{b}	9.4^{cd}	8.5^{d}	10.3^{c}	12.5^{b}	16.3^{a}	60.95*
Stews	8.9	8.9	–0.13	2.9^{e}	5.4^{f}	7.9^{cd}	7.4^{d}	7.4^{d}	9.0^{bc}	10.1^{b}	13.1^{a}	41.66*
Steamed foods	1.9	1.5	3.73*	2.2^{a}	1.8^{a}	1.9^{a}	1.6^{ab}	2.0^{a}	1.8^{a}	1.6^{ab}	1.1^{b}	3.49*
Grilled foods	5.5	4.8	4.72*	9.2^{a}	7.7^{b}	6.5^{c}	5.2^{cd}	5.7^{d}	5.2^{d}	4.2^{e}	3.0^{f}	35.05*
Pan-fried foods	1.4	1.6	–1.81	3.3^{a}	3.2^{a}	2.5^{b}	1.9^{c}	1.6^{c}	1.5^{c}	0.9^{d}	0.6^{d}	43.28*
Stir-fried foods	4.9	4.8	0.97	3.4^{e}	5.5^{cd}	5.9^{bc}	6.8^{ab}	7.0^{a}	5.0^{d}	3.0^{e}	2.0^{f}	67.68*
Braised foods	1.9	2.0	–0.61	2.6^{a}	2.6^{a}	2.6^{a}	2.3^{ab}	1.7^{c}	1.8^{bc}	1.9^{bc}	1.9^{bc}	6.62*
Fried foods	1.9	1.9	0.47	1.7^{c}	2.2^{b}	3.5^{a}	3.4^{a}	3.4^{a}	1.4^{c}	0.6^{d}	0.3^{d}	85.76*
Cooked-seasoned vegetables	2.1	2.4	–4.35	1.3^{c}	1.4^{c}	1.2^{c}	1.1^{c}	1.5^{c}	2.5^{b}	3.3^{a}	3.1^{a}	45.70*
Salads	2.8	3.0	–1.74	0.9^{e}	1.6^{d}	1.9^{cd}	2.6^{bc}	3.3^{a}	3.2^{a}	3.1^{ab}	2.5^{bc}	14.06*
Kimchi	22.9	23.1	–0.53	6.8^{f}	11.6^{e}	15.2^{d}	17.4^{c}	18.7^{c}	24.7^{b}	29.3^{a}	30.0^{a}	224.54*
Salt-fermented foods	0.9	0.6	4.05	0.0^{d}	0.1^{d}	0.3^{d}	0.4^{cd}	0.7^{bc}	0.7^{bc}	1.1^{ab}	1.4^{a}	14.36*
Pickled foods	2.1	2.8	–5.98	0.7^{c}	0.8^{c}	1.0^{c}	1.8^{b}	2.6^{a}	2.9^{a}	2.7^{a}	2.2^{ab}	17.36*
Seasonings	5.0	4.2	5.21	2.6^{d}	3.1^{cd}	3.8^{bc}	4.2^{b}	3.9^{bc}	5.3^{a}	5.1^{a}	4.2^{b}	13.11*
Others	5.0	6.1	–8.19	23.4^{a}	13.6^{b}	7.5^{c}	5.3^{d}	5.9^{de}	4.4^{ef}	4.7^{ef}	3.8^{g}	286.47*

*: $p < 0.0001$

1) Sodium intake contribution of each dish group(%)

2) a, b, c: Mean with by different superscripts are significantly different by Duncan's multiple range test

소금 섭취량의 주요 급원음식

Table 4. Comparison of top 20 individual dishes contributing to total sodium intake of subjects by sex

Rank	Total				Male				Female			
	Dish	Mean (mg)	Contribution (%)	Cum%[1)]	Dish	Mean (mg)	Contribution (%)	Cum%	Dish	Mean (mg)	Contribution (%)	Cum%
1	배추김치	713	15.5	15.5	배추김치	877	16.3	16.3	배추김치	549	14.4	14.4
2	라면	208	4.5	20.0	라면	274	5.1	21.4	총각김치	160	4.2	18.6
3	총각김치	159	3.5	23.5	된장국	179	3.3	24.7	라면	142	3.7	22.3
4	된장국	157	3.4	26.9	총각김치	158	2.9	27.7	된장국	134	3.5	25.8
5	미역국	120	2.6	29.5	김치찌개	142	2.6	30.3	미역국	113	3.0	28.8
6	김치찌개	118	2.6	32.1	미역국	126	2.3	32.6	김치찌개	94	2.5	31.3
7	된장찌개	90	2.0	34.0	쌈장	109	2.0	34.7	된장찌개	87	2.3	33.6
8	쌈장	82	1.8	35.8	된장찌개	93	1.7	36.4	양파장아찌	65	1.7	35.3
9	국수	69	1.5	37.3	국수	76	1.4	37.8	국수	61	1.6	36.9
10	청국장찌개	66	1.4	38.8	청국장찌개	75	1.4	39.2	잡곡밥	61	1.6	38.5
11	잡곡밥	64	1.4	40.2	깍두기	71	1.3	40.5	청국장찌개	58	1.5	40.0
12	양파장아찌	62	1.4	41.5	쌀밥	70	1.3	41.8	쌈장	56	1.5	41.5
13	쌀밥	57	1.2	42.7	잡곡밥	66	1.2	43.0	칼국수	49	1.3	42.7
14	깍두기	57	1.2	44.0	짜장면	64	1.2	44.2	열무김치	48	1.3	44.0
15	칼국수	53	1.2	45.1	돼지고기볶음	64	1.2	45.4	나박김치	45	1.2	45.2
16	고추장	48	1.0	46.2	고추장	63	1.2	46.6	쌀밥	43	1.1	46.3
17	열무김치	47	1.0	47.2	돼지고기찜	59	1.1	47.7	깍두기	42	1.1	47.4
18	돼지고기볶음	44	1.0	48.1	양파장아찌	59	1.1	48.8	우유	36	1.0	48.4
19	짜장면	44	1.0	49.1	칼국수	58	1.1	49.9	김구이	35	0.9	49.3
20	비빔밥	42	0.9	50.0	삼겹살구이	55	1.0	50.9	고추장	33	0.9	50.1

1) Cumulative percentage

SALT INTAKE AND BLOOD PRESSURE

Salt and BP

- *Salt and sodium*
  - The terms salt and sodium are often used synonymously.
  - Salt = 40% sodium, 60% chloride
  - 1g sodium = 2.5g salt; 1mmol sodium=23mg sodium; 1g salt = 0.4g sodium; 1g salt = 17mmol sodium
  - Salt is the major source of sodium in the diet(90%)

- *Salt and BP*
  - Salt is a major factor for increased BP.
  - Raised BP is major cause of CVD, responsible for 62% of stroke and 49% of coronary heart disease.

Salt and BP

Epidemiological Studies

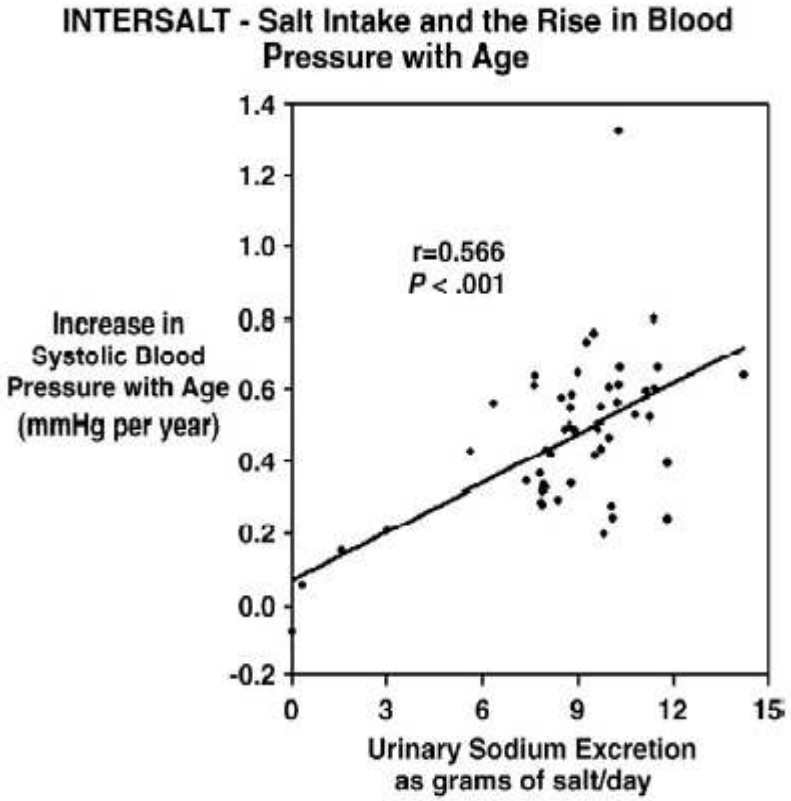


Fig 2. Relationship between salt intake and the slope of the rise in systolic BP with age in 52 centers in the INTERSALT study. Adapted from INTERSALT.[2]

대규모 다국적연구(INTERSALT)에서 소변내 소금배설량이 증가할수록 수축기혈압이 상승함

BMJ 297(30): 319-328, 1988

Salt and BP

Treatment Trials

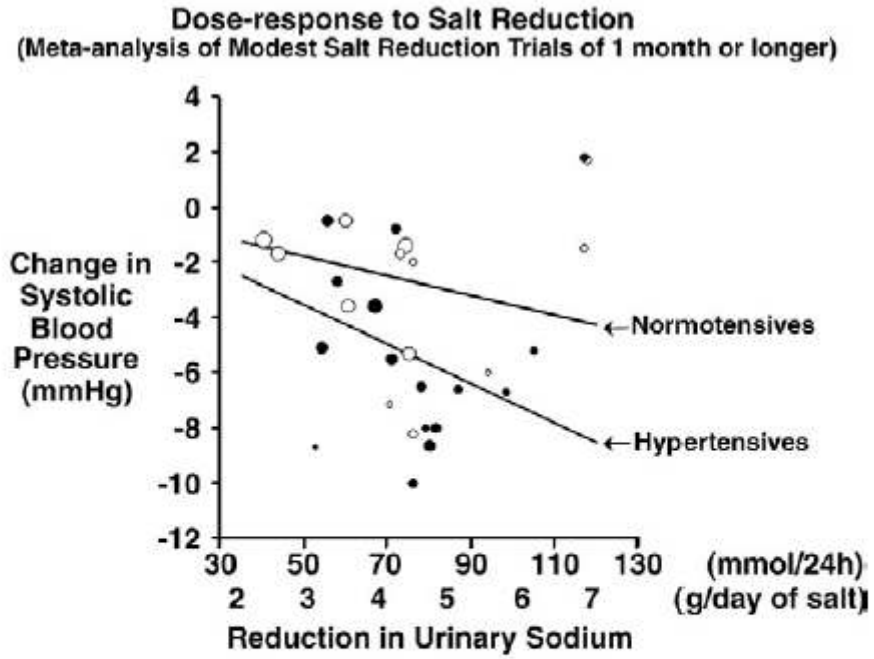


Fig 4. Relationship between the reduction in 24-hour urinary sodium and the change in blood pressure in a meta-analysis of modest salt reduction trials. The open circles represent normotensive subjects and the solid circles represent hypertensive subjects. The slope is weighted by the inverse of the variance of the net change in BP. The size of the circle is in proportion to the weight of the trial.

고혈압 대상자 연구 17개(734명), 비고혈압 대상자 연구 11개 (2,220명)를 메타분석한 결과, 중정도의 소금 섭취(5-6g/d)감소를 4주이상 유지시 고혈압, 비고혈압 대상자 모두에서 혈압에 유의한 영향을 미침

J Hum Hypertens 16:761-770, 2002

Salt and HTN prevention

Intervention Studies

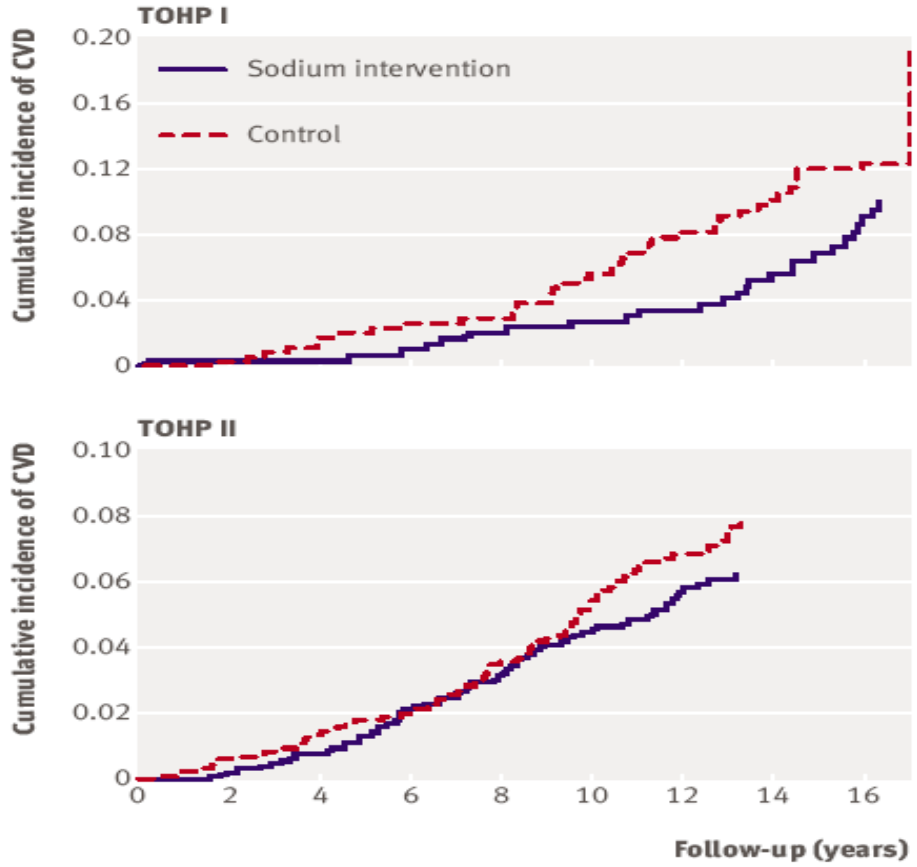


Fig 2 | Cumulative incidence of cardiovascular disease (CVD) by sodium intervention group in TOHP I and II, adjusted for age, sex, and clinic

대규모 무작위 연구(TOHP I, TOHP II, N=2415)에서
소금 섭취 25-30% 감소시 CVD 위험을 25% 감소시켰음

Salt and Mortality

Mortality Studies

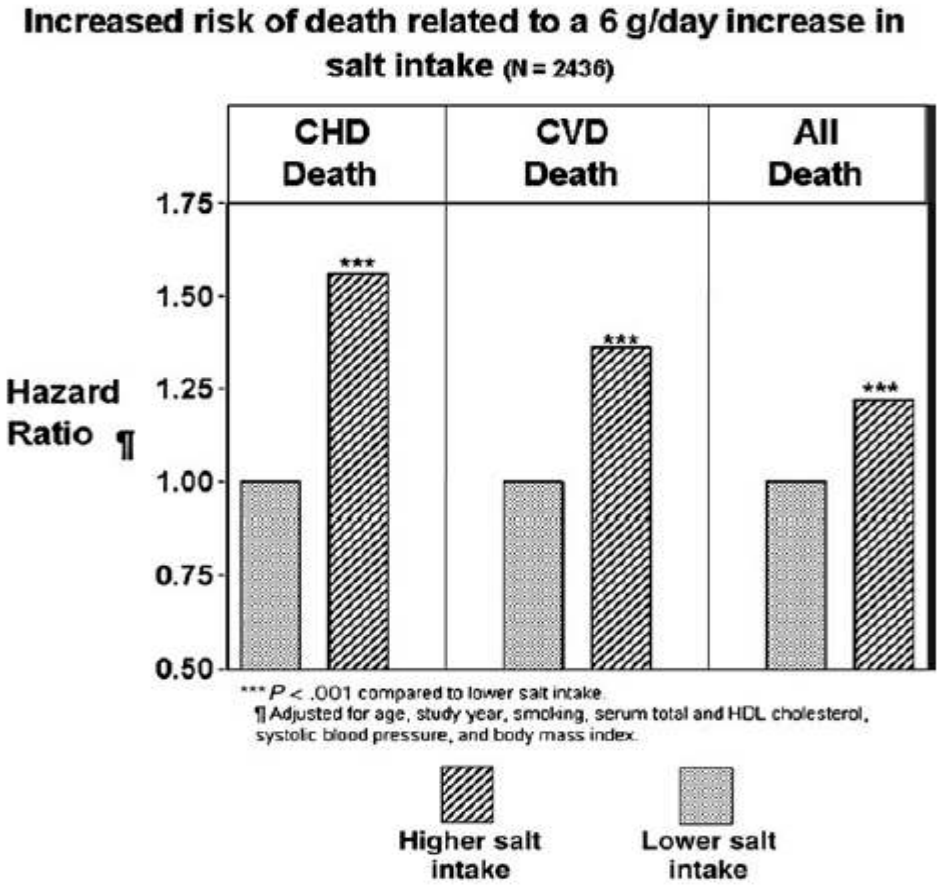


Fig 8. The hazards ratios for CHD, CVD, and all-cause mortality associated with a 6 g/d increase in salt intake as judged by 24-hour urinary sodium excretion. Adapted from Tuomilehto et al.[5]

Prospective cohort study(Finnish, N= 2436)에서, 소금 6g 증가시 CHD death 56%, CVD death 36%, all death 22% 증가하였음

Lancet 17;357(9259):848-51, 2001

SALT SENSITIVITY

Salt Sensitivity

- Variations in BP response to salt reduction.
- Tendency for BP to fall during salt reduction and rise during salt repletion/supplementation.
- Salt sensitivity and resistance
  genetic factors, race/ethnicity, age, body mass, diet,
  disease states (HTN, DM and renal dysfunction)
- Prevalence
  51% of hypertensives, 26% of normotensives (Franco et al, 2006)
- Salt sensitivity is a risk factor for cardiovascular morbidity and mortality.

(Morimoto et al1997)

Salt Sensitive

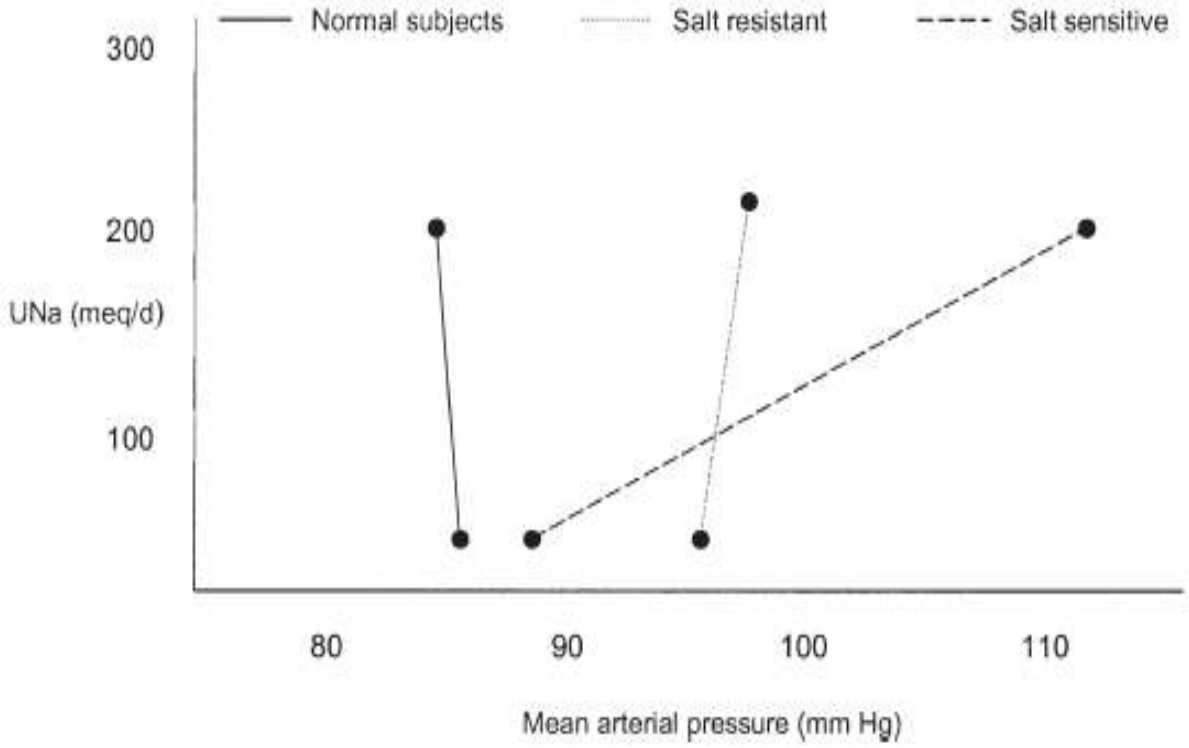


Fig 1. Pressure-natriuresis curve in healthy subjects and patients with essential hypertension who are either salt resistant or salt sensitive. (Reprinted with permission.[17])

Salt Sensitivity- long term consequences

Treatment Trials

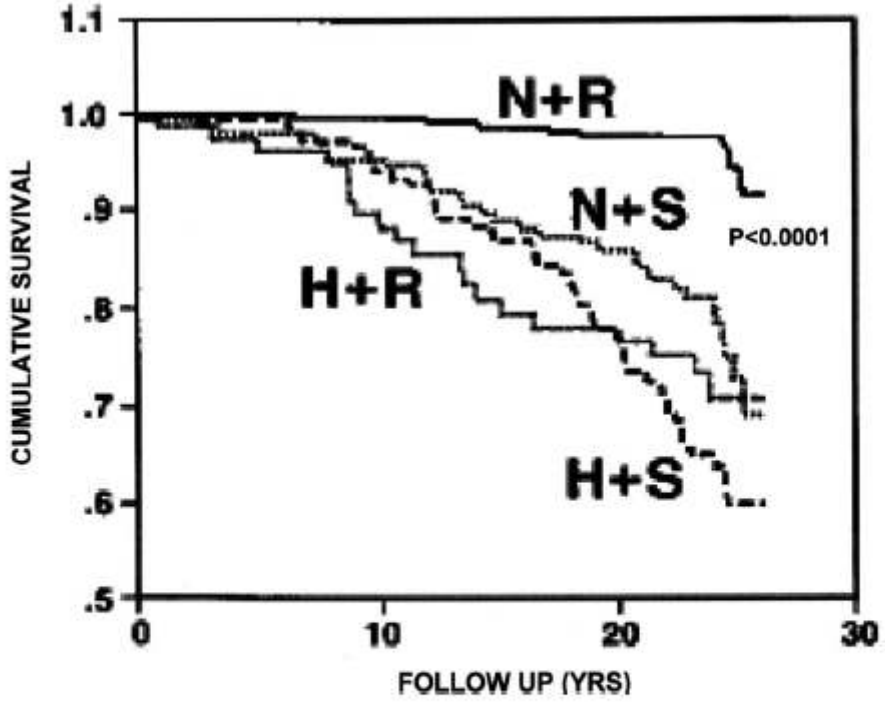


Fig. 2. Kaplan-Meier survival curves for normotensive salt-resistant individuals (N+R), normotensive salt-sensitive individuals (N+S), hypertensive salt-resistant individuals (H+R), and hypertensive salt-sensitive individuals (H+S) over the follow-up period. As noted, only the N+R group had an increased survival. Reprinted with permission from Weinberger et al. [19].

고혈압군(N=278), 정상군(N=430)을 27년 추적한 결과,
소금 민감성과 사망률은 관련성이 있으며, BP 상승의 독립적인 인자임.

Hypertension 37:429-432, 2001

Salt Sensitivity- long term consequences

Mortality studies

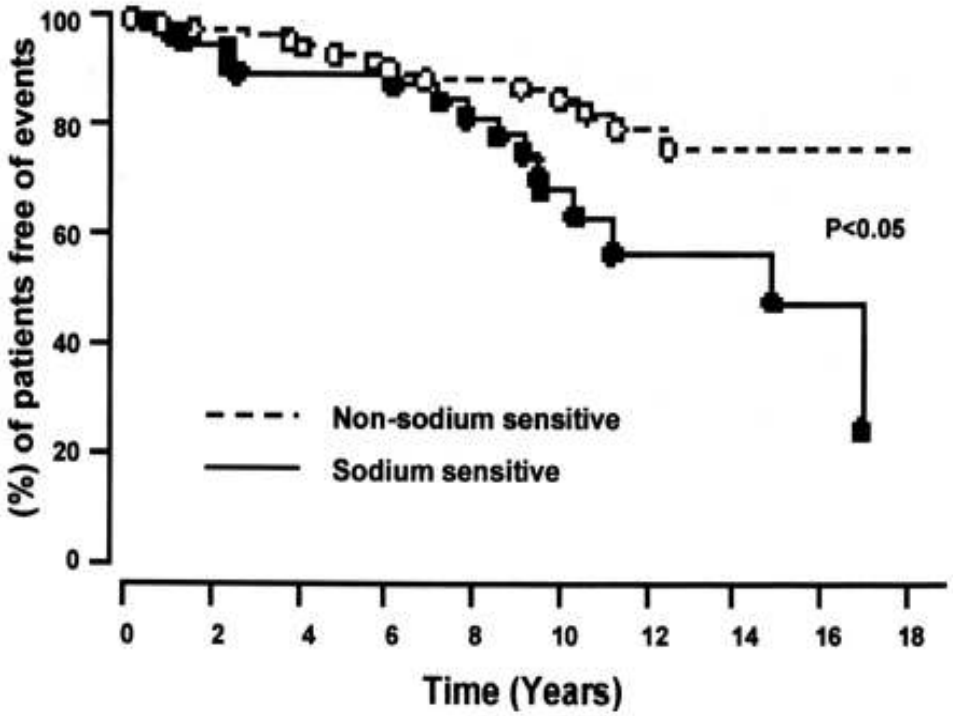


Fig. 3. Kaplan-Meier plots of total cardiovascular events by sodium sensitivity. Reprinted with permission from Morimoto et al. [20].

N= 350 Japanese with HTN, Sodium sensitivity군에서 CVD event가 높았음. Sodium sensitivity는 CVD risk factor 예측하는 독립적인 인자임.

Lancet 350:1734-1737, 2001

SALT INTAKE AND DIABETES

Hypertension with Diabetes

- HTN is a Major risk factor for CVD and microvascular complications.
- HTN is an extremely common comorbidity of diabetes.
- Diabetes is at increased risk for vascular disease.
- Diabetes makes it more likely to develop high BP, which increases the risk of strokes, heart attacks and speeds up the progression of diabetic kidney disease.

Table 2. Proportion of diabetic complications attributable to hypertension*

COMPLICATION	ATTRIBUTABLE RISK, %
Stroke	75
Coronary artery disease	35
End-stage renal disease	50
Eye disease†	35
Leg amputation	35

BP—blood pressure.
Data from Bild and Teutsch.[4]
*Hypertension has been defined as BP > 160/95 mm Hg or BP > 140/90 mm Hg, depending on the study.[4,5]
†Retinopathy.

Prevalence

- Diabetic population is **3 times** higher than that of nondiabetic age-matched group.

- Timing and presentation of HTN differs between T1DM and T2DM.
  - T1DM: after several yrs of the disease
  - T2DM: at the time of diagnosis or even before

- Approximately **20-60%** of patients with T2DM will develop HTN, depending on age, ethnicity, and obesity

- Diabetic individuals with hypertension have greatly increased risks of cardiovascular disease, renal insulfficiency, and diabetic retinopathy.

- Relationship between diabetic neuropathy and arterial hypertension is less clear.

Diabetes and CVD

제 2형 당뇨병환자의 사망원인에 대한 10년간의 추세변화
- 부산시내 6개 종합병원을 중심으로-

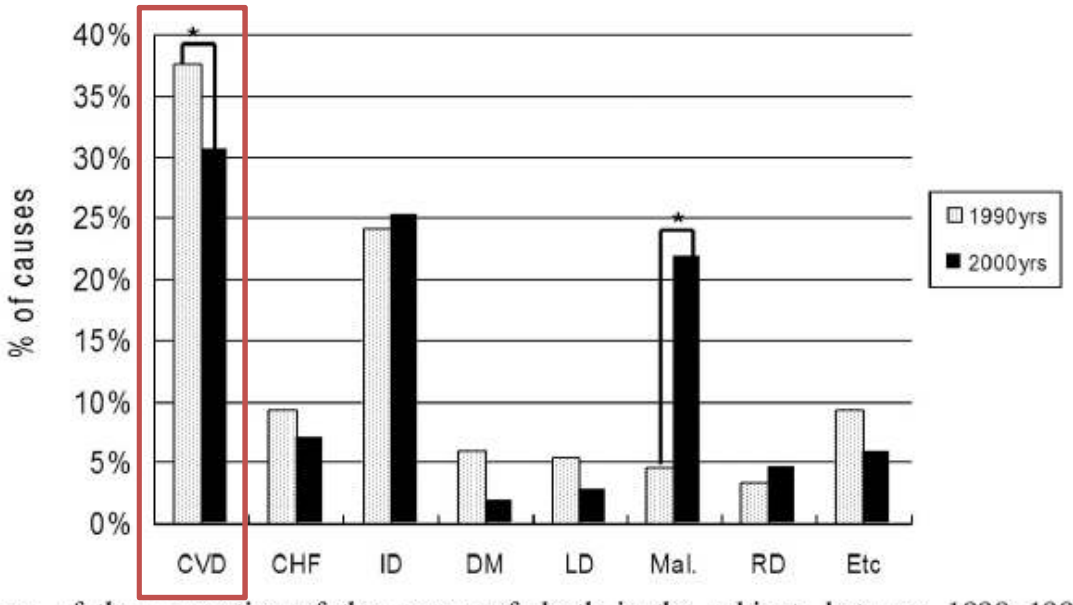


Fig. 1. The comparison of the proportion of the causes of death in the subjects between 1990~1994 and 2000~2004. * $P < 0.001$. CHF, congestive heart failure; CVD, cardiovascular disease; DM, diabetes mellitus; Etc, others; ID, infectious disease; LD, liver disease; Mal., malignancy; RD, renal disease.

당뇨병 환자 사망원인의 30.6% CVD에 의함

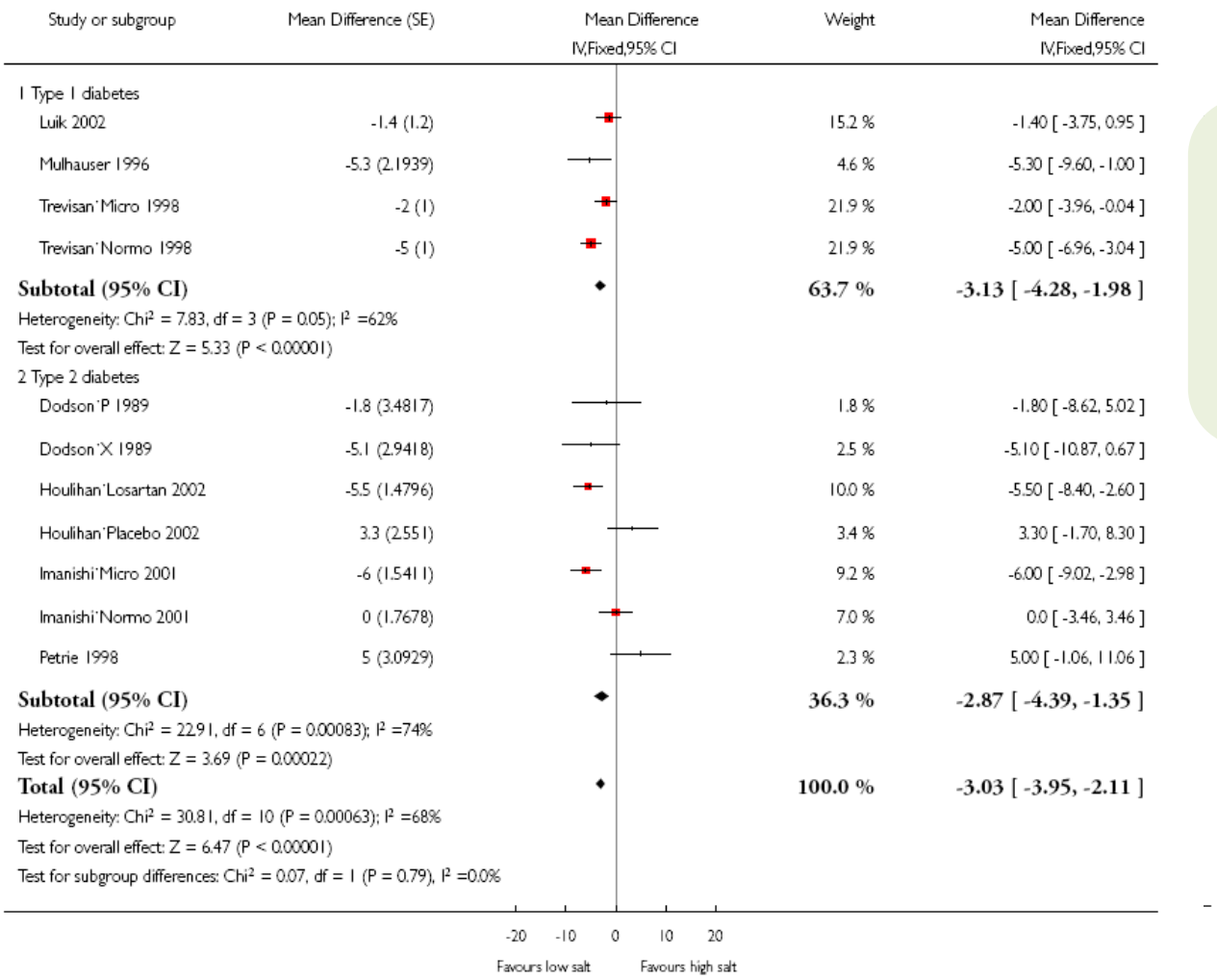
Salt, BP and Diabetes

Analysis 2.2. Comparison 2 Net change in BP in type 1 and type 2 diabetes, Outcome 2 Diastolic BP.

Review: Altered dietary salt intake for preventing and treating diabetic kidney disease

Comparison: 2 Net change in BP in type 1 and type 2 diabetes

Outcome: 2 Diastolic BP



Meta-analysis결과, 소금섭취량을 8.5g/d 감소시 T1DM, T2DM 모두 혈압 7/3mmHg 강하되었음

DASH diet in T2DM

Table 4. Multiple logistic regression analyses: daily intake of Dietary Approaches to Stop Hypertension (DASH) diet food groups and their OR for HIGH mean blood pressure (MBP) values (dependent variable)

(Odd ratios and 95 % confidence intervals)

HIGH MBP (MBP ≥ 92 mmHg)	OR	95 % CI	*P**
Fruits			
1 portion (80 g) per 4184 kJ (1000 kcal)	0·781	0·617, 0·987	0·039
Weight (g/kg)	0·896	0·790, 1·016	0·087
> 2·1 portions per 4184 kJ (1000 kcal)†	0·561	0·292, 1·078	0·083
Vegetables			
1 portion (50 g) per 4184 kJ (1000 kcal)	0·781	0·618, 0·988	0·040
Weight (g/kg)	0·856	0·704, 1·039	0·116
> 2·1 portions per 4184 kJ (1000 kcal)†	0·504	0·271, 0·937	0·030
Oils and fat			
1 portion (5 ml) per 4184 kJ (1000 kcal)	0·878	0·702, 1·097	0·252
Weight (ml/kg)	0·518	0·052, 5·165	0·575
≤ 1·2 portions per 4184 kJ (1000 kcal)†	0·804	0·322, 2·010	0·641
Whole grains			
1 portion (20 g) per 4184 kJ (1000 kcal)	1·025	0·898, 1·170	0·716
Weight (g/kg)	1·047	0·815, 1·346	0·718
> 3·6 portions per 4184 kJ (1000 kcal)†	0·718	0·285, 1·809	0·482
Sweets			
1 portion (5 g) per 4184 kJ (1000 kcal)	0·789	0·554, 1·123	0·188
Weight (g/kg)	0·855	0·550, 1·327	0·484
≤ 0·33 portions per 4184 kJ (1000 kcal)†	1·695	0·883, 3·253	0·113
Dairy foods			
1 portion (120 ml) per 4184 kJ (1000 kcal)	0·961	0·710, 1·301	0·796
Weight (g/kg)	1·007	0·903, 1·124	0·899
> 0·96 portions per 4184 kJ (1000 kcal)†	0·772	0·421, 1·418	0·404

* Regression models adjusted for abnormal waist circumference, urinary albumin excretion, diabetes duration and HbA1c.

† Recommended portions in the DASH diet eating plan.

Cross sectional study, N=225(T2DM)

- 24UNa과 혈압과는 관련이 없었음
- 24UNa과 채소, 과일 섭취와는 상관관계가 있음

24UNa and mortality (T2DM)

Prospective cohort study, 11yr f/u, n= 638 T2DM, 24hUNa
24hUna에서 100mml(NaCl 5.8g)상승시, all-cause mortality가 28%감소함(p=.02).

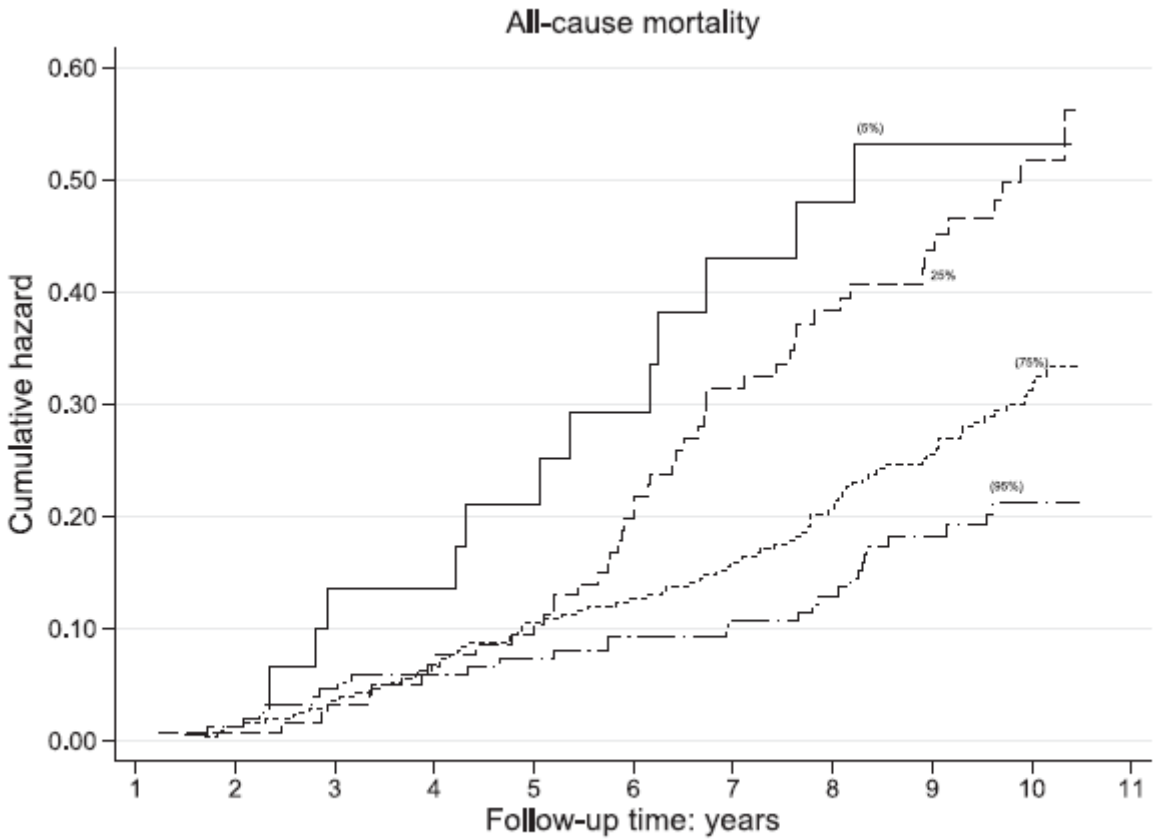


Figure 1—*Cumulative hazard (Nelson-Aalen) of all-cause mortality, stratified by percentiles (5th, 25th, 75th, and 95th) of 24-h urinary sodium excretion. All-cause mortality was inversely associated with 24-h urinary sodium excretion.*

Diabetes Care 34:703-709, 2011

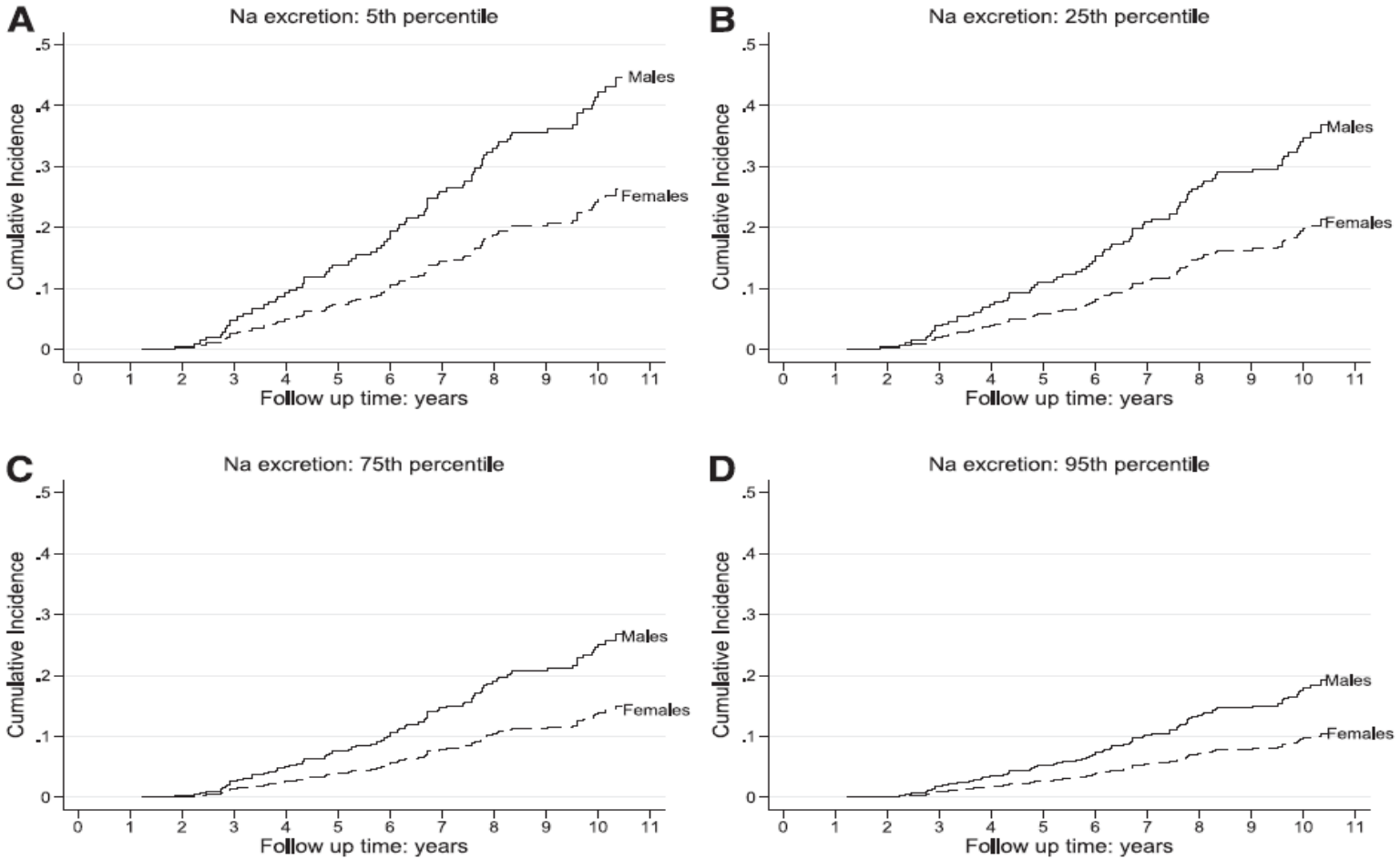


Figure 2—*The cumulative incidence (Fine and Gray) of cardiovascular mortality over the 5th, 25th, 75th, and 95th percentile (A–D, respectively) of 24-h urinary sodium excretion in men and women (solid line and dotted line, respectively), adjusted for other covariate predictors (Table 2) and accounting for noncardiovascular mortality as the competing risk. The other predictors are set at: eGFR = 76.6 mL/min/1.73 m^2 (median); atrial fibrillation = yes; preexisting cardiovascular disease = yes; Log_{10} AER = 1.2 (median); systolic blood pressure = 140 mmHg (mean); diabetes duration = 10.4 years (median).*

24UNa and mortality (T1DM)

- Nationwide multicenter study, T1DM without ESRD (n=2,807)
- Urinary sodium excretion was inversely associated with the cumulative incidence of ESRD, such that individuals with the lowest sodium excretion had the highest cumulative incidence of ESRD.

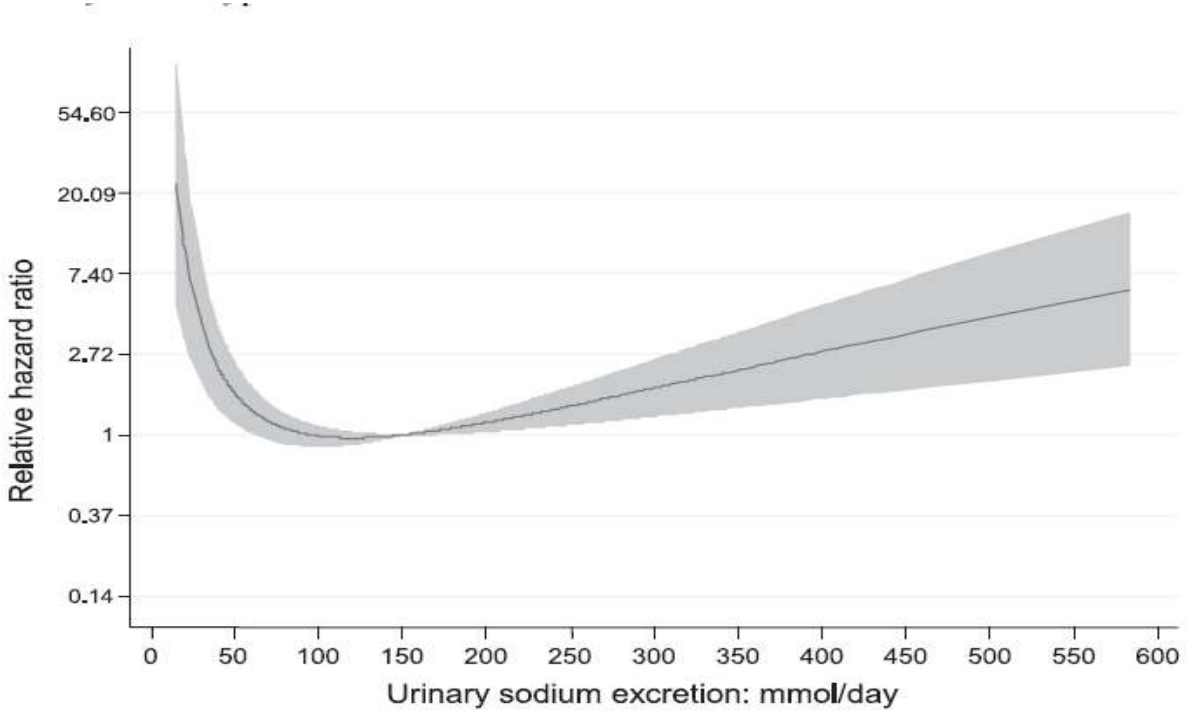


Figure 1—*The association between 24-h urinary sodium excretion and all-cause mortality modeled within the conventional Cox model as a cubic regression spline presented as Supplementary Table 2.*

Diabetes Care 34:861-866, 2011

Salt and kidney disease

Treatment Trials

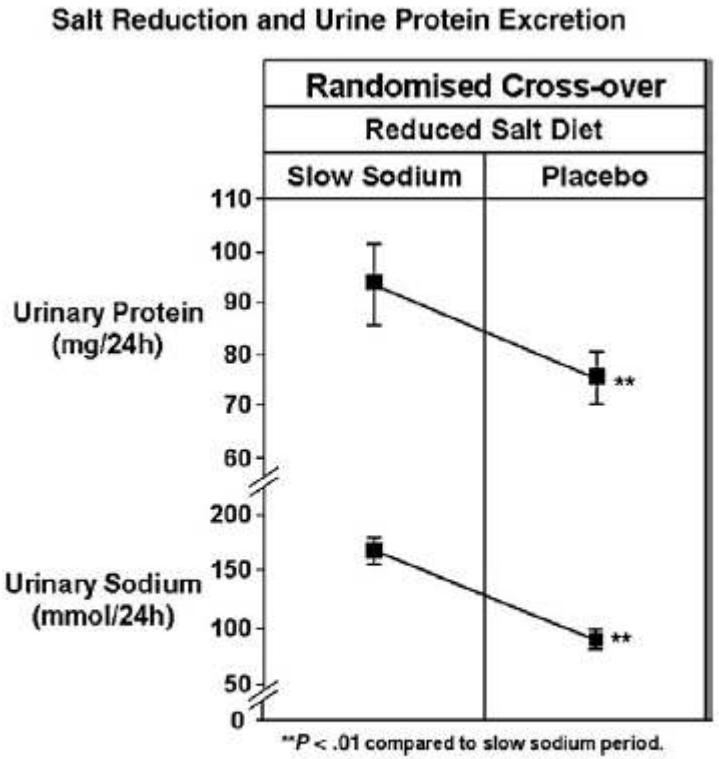


Fig 13. Change in urinary sodium and protein excretion with a modest reduction in salt intake from approximately 10 to 5 g/d in 40 hypertensive blacks.

Randomized double-blind trial (N= 40, hypertensive blacks)에서, 소금섭취를 10g→5g으로 줄였을때 24hr U protein 19%(P<.01)감소함

Hypertension 46:308-312, 2005

Salt and kidney disease

Treatment Trials

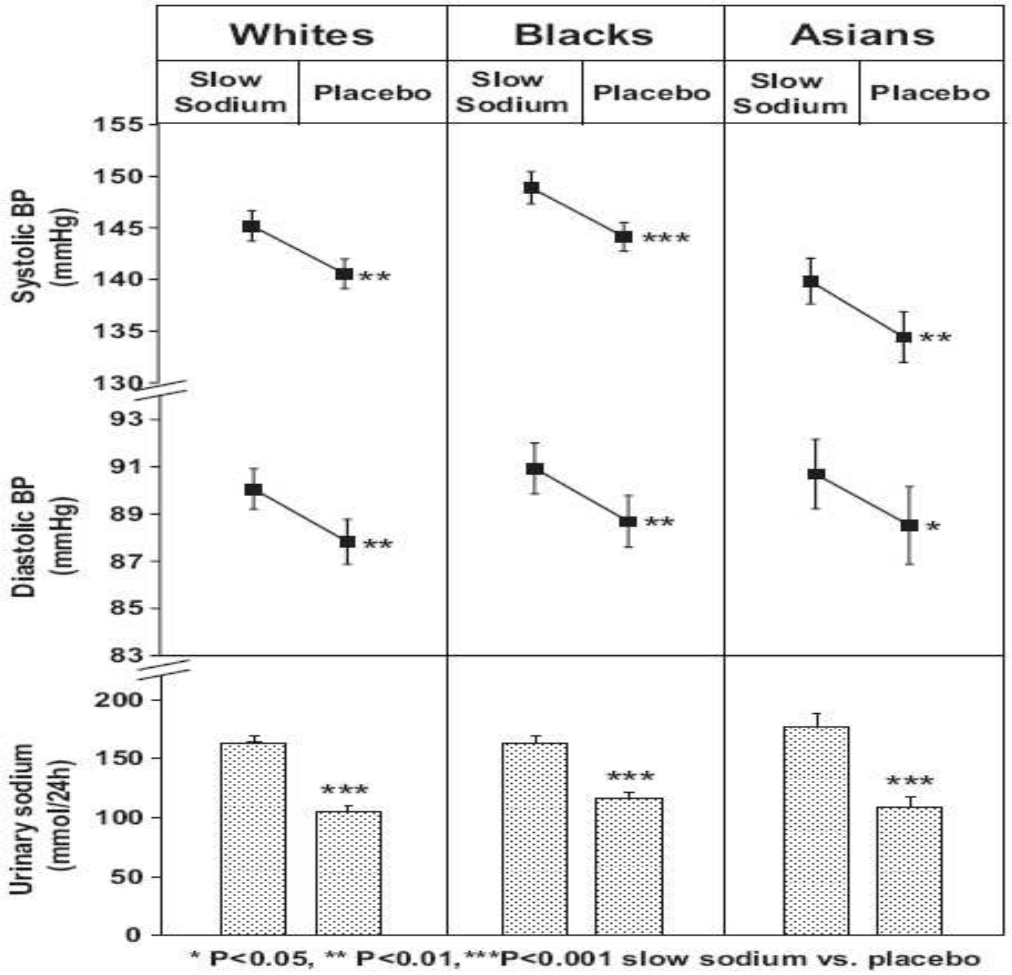


Figure. Blood pressure (BP) and urinary sodium excretion (mean±SEM) after 6 weeks on each phase of crossover trial in white (n=71), black (n=69), and Asian (n=29) hypertensive individuals.

Randomized double-blind crossover trial(6wks, 71 whites, 69 blacks, 29 asians with hypertensive)에서, 소금섭취감소는 모든군에서 24hr urinary albumin 배설량을 평균 9.7→6.5g 감소시켰다.

Hypertension 54:482-488, 2009

Effect of sodium intake on BP and albuminuria in T2DM

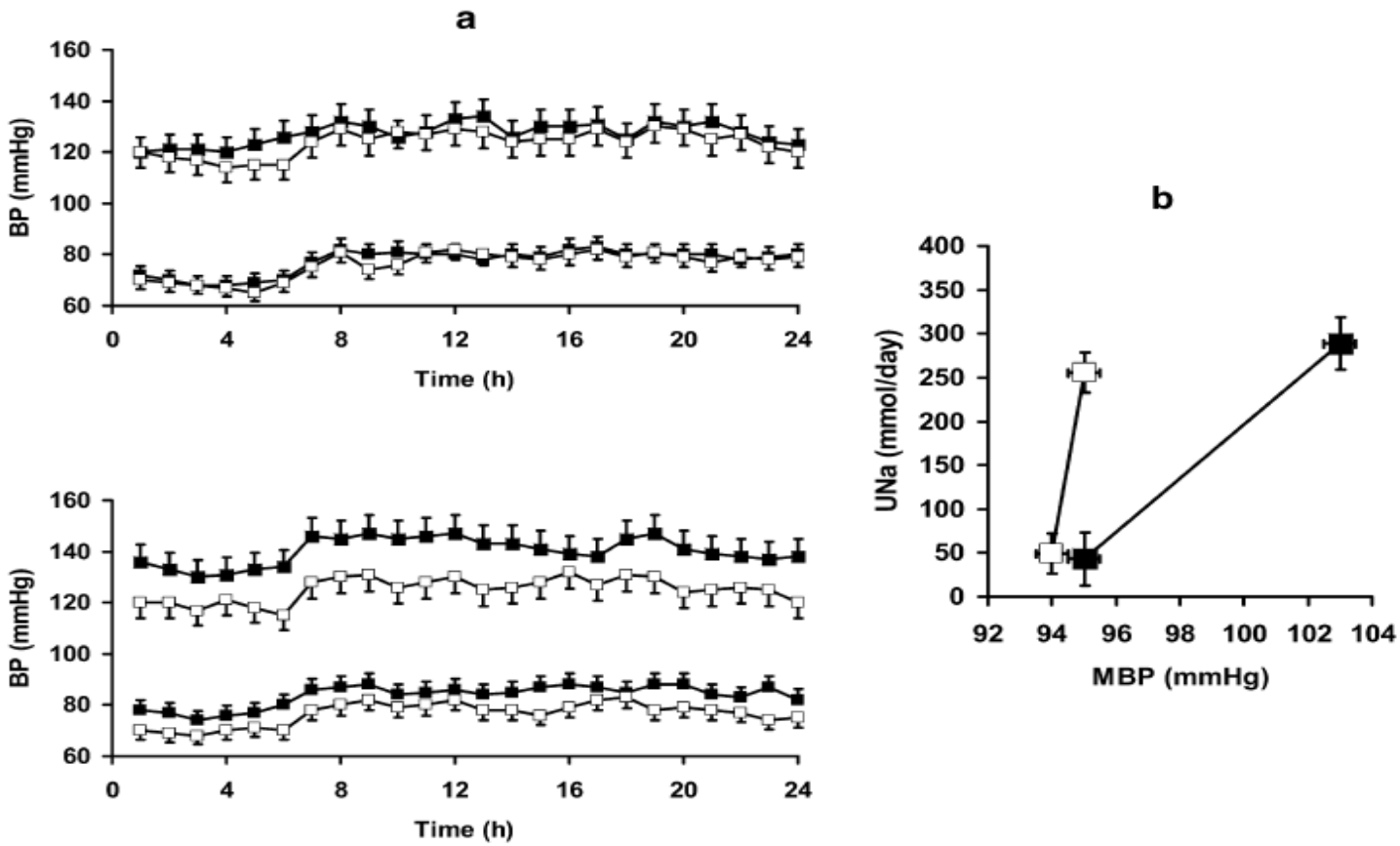


Fig. 1. a 24-h profile of mean ± SEM of mean systolic and diastolic blood pressure in Type 2 diabetic patients with (■) and without (□) microalbuminuria after a low (upper panel) or a high-sodium diet (lower panel). **b** Association (pressure-natriuresis curve) between sodium urinary excretion (UNa) and mean blood pressure (MBP) in Type 2 diabetic patients with (■) and without (□) microalbuminuria

T2DM, 21명(+미세알부민뇨), 21(-미세알부민뇨), 고염식(250mmol) vs 저염식(20mmol)
고염식은 미세알부민뇨가 있는 당뇨병환자에서 혈압과 단백뇨를 증가시킴

Diabetologia 47:300-303, 2004

BP and diabetic nephropathy

- Results From the RENALL Study

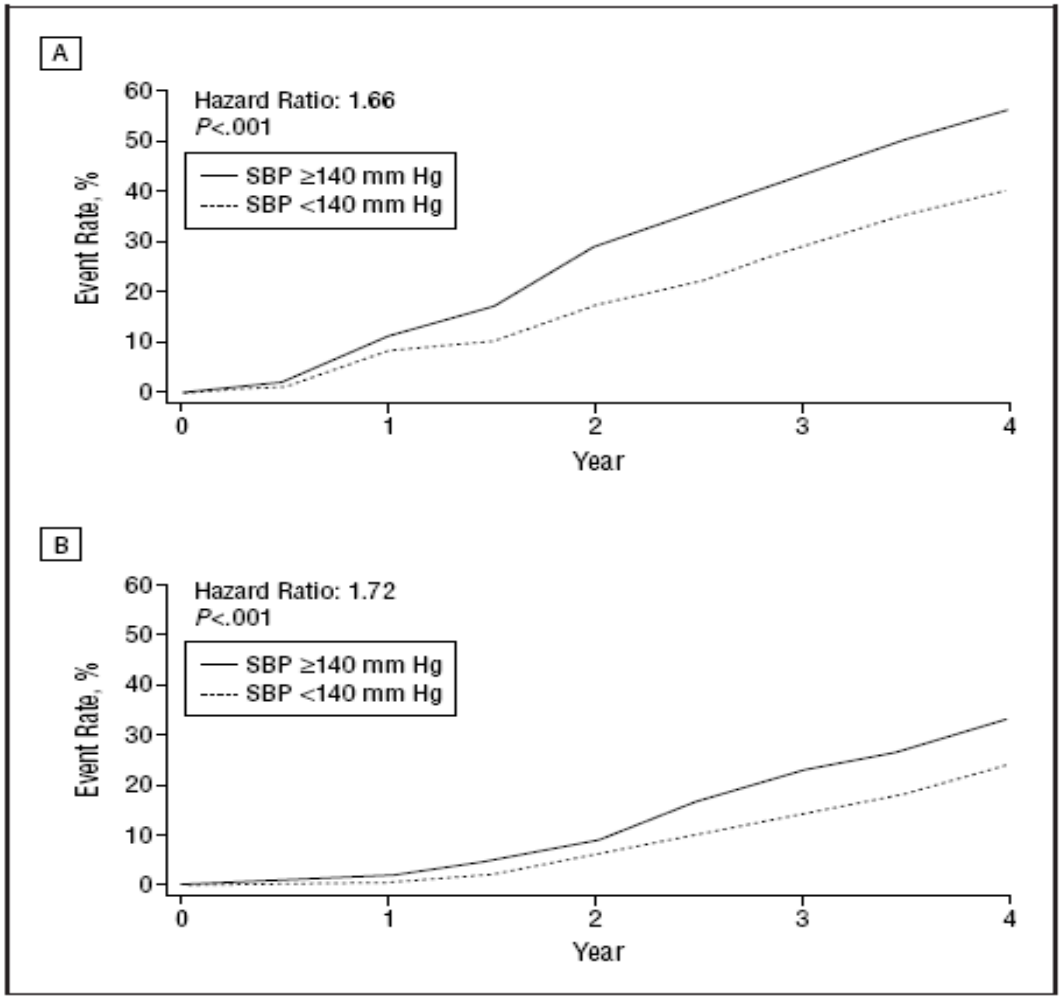


Figure 1. A, Event rate for the primary composite end point by baseline systolic blood pressure (SBP). B, Event rate for end-stage renal disease alone by baseline SBP.

- RCT, N=1,513
- SBP 상승시 사망률과 관련있음
- 특히, SBP 140이상인 경우 신장질환의 위험 증가

Arch Intern Med 163:1555-1565, 2003

Salt and retinopathy (T1DM)

High caloric and sodium intakes as risk factors for progression of retinopathy in type 1 diabetes mellitus

Table 2. Univariate Analysis of the Relationship of Baseline Dietary Nutrient Intakes to 6-Year Progression of Diabetic Retinopathy in Type 1 Diabetes Mellitus

Baseline Dietary Nutrient Intake	VTDR		ME		Severe HEs	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Total calories, kcal	1.39 (1.11-1.75)	.004	1.18 (0.94-1.49)	.16	1.48 (1.15-1.91)	.003
Carbohydrate, g	1.29 (1.03-1.62)	.03	1.08 (0.85-1.36)	.54	1.34 (1.05-1.72)	.02
Protein, g	1.36 (1.08-1.70)	.009	1.18 (0.93-1.49)	.17	1.42 (1.10-1.83)	.007
Total fat, g	1.36 (1.08-1.71)	.009	1.15 (0.91-1.45)	.25	1.43 (1.11-1.84)	.006
Saturated fat, g	1.01 (1.002-1.03)	.03	1.01 (0.99-1.02)	.32	1.02 (1.002-1.03)	.02
Oleic acid, g	1.40 (1.11-1.77)	.004	1.18 (0.93-1.49)	.17	1.44 (1.12-1.86)	.005
Linoleic acid, g	1.33 (1.06-1.66)	.01	1.14 (0.90-1.44)	.27	1.35 (1.06-1.73)	.02
Fiber, g	1.23 (0.99-1.53)	.07	1.20 (0.95-1.52)	.13	1.20 (0.94-1.53)	.15
Cholesterol, mg	1.39 (1.11-1.74)	.004	1.21 (0.95-1.53)	.11	1.36 (1.06-1.74)	.02
Sodium, mg	1.37 (1.09-1.72)	.008	1.31 (1.03-1.66)	.03	1.36 (1.06-1.76)	.02

Abbreviations: CI, confidence interval; HEs, hard exudates; ME, macular edema; OR, odds ratio; VTDR, vision-threatening diabetic retinopathy.

T1DM=469, FFQ, 6yr f/u, progression of diabetic retinopathy
T1DM환자에서 소금 섭취는 DR와 유의적이며, DR진행에 독립적인 위험인자임

Arch ophthalmol 128(1) : 33-39, 2010

MANAGEMENT OF HTN IN DIABETES

Behavioral treatments of HTN

- Dietary management with moderate sodium restriction has been effective in reducing BP in HTN patients.

- Relationship between wt. loss and BP reduction.
  - Wt. reduction → BP ↓, improve blood glucose and lipid levels
  - 1kg/Bwt ↓ → 1mmHg ↓

- Moderate intense physical activity, smoking cessation and moderate of alcohol have been shown to lower BP (JNC VI)

- Micronutrients - Calcium, magnesium, potassium

Diabetes Care 25(1)134-147, 2002

TABLE 9. Lifestyle Modifications To Prevent and Manage Hypertension*

Modification	Recommendation	Approximate SBP Reduction (Range)†
Weight reduction	Maintain normal body weight (body mass index 18.5–24.9 kg/m^2).	5–20 mm Hg/10 kg[92,93]
Adopt DASH eating plan	Consume a diet rich in fruits, vegetables, and low-fat dairy products with a reduced content of saturated and total fat.	8–14 mm Hg[94,95]
Dietary sodium reduction	Reduce dietary sodium intake to no more than 100 mmol per day (2.4 g sodium or 6 g sodium chloride).	2–8 mm Hg[94–96]
Physical activity	Engage in regular aerobic physical activity such as brisk walking (at least 30 minutes per day, most days of the week).	4–9 mm Hg[97,98]
Moderation of alcohol consumption	Limit consumption to no more than 2 drinks (eg, 24 oz beer, 10 oz wine, or 3 oz 80-proof whiskey) per day in most men and to no more than 1 drink per day in women and lighter-weight persons.	2–4 mm Hg[99]

DASH indicates Dietary Approaches to Stop Hypertension.

*For overall cardiovascular risk reduction, stop smoking.

†The effects of implementing these modifications are dose- and time-dependent and could be greater for some individuals.

WHO/FAO recommendation

Table 2 Ranges of population nutrient intake goals (% of total energy, unless otherwise stated)

Dietary factor	1989 WHO Study Group recommendations[2]	2002 Joint WHO/FAO Expert Consultation recommendations[1]	Rationale for Joint WHO/FAO Expert Consultation recommendations
Total fat	15–30%	15–30%	Obesity/CVD/diabetes
Saturated fatty acids (SFAs)	0–10%	<10%	Diabetes/CVD
Polyunsaturated fatty acids (PUFAs)	3–7%	6–10%	CVD
n-6 PUFAs		5–8%	CVD
n-3 PUFAs		1–2%	CVD
Trans fatty acids		<1%	CVD
Monounsaturated fatty acids (MUFAs)		By difference*	
Total carbohydrate	55–75%	55–75%†	
Free sugars‡	0–10%	<10%	Obesity/dental diseases
Complex carbohydrate	50–70%	No recommendation	
Protein	10–15%	10–15%§	
Cholesterol	0–300 mg/day	<300 mg/day	CVD
Sodium chloride (Sodium)‖	<6 g/day	<5 g/day (<2 g/day)	CVD
Fruits and vegetables	≥400 g/day	≥400 g/day	CVD/cancer
Pulses, nuts and seeds	≥30 g/day (as part of the 400 g of fruit and vegetables)		
Total dietary fibre	27–40 g/day	From foods	
NSP	16–24 g/day	From foods	Obesity/diabetes/CVD/Cancer

*This is calculated as: total fat − (SFAs + PUFAs + *trans* fatty acids).
†The percentage of total energy available after taking into account that consumed as protein and fat, hence the wide range.
‡The term 'free sugars' refers to all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and fruit juices.
§The suggested range should be seen in the light of the Joint WHO/FAO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition, held in Geneva from 9 to 16 April 2002[4].
‖Salt should be iodized appropriately[5]. The need to adjust salt iodization, depending on observed sodium intake and surveillance of iodine status of the population, should be recognized.

Public Health Nutr. 2004 Feb;7(1A):245-50

각 국의 권고기준

국 가	권 고 량	출 처
미 국	Sodium 2300mg/day(소금 약 6g) 심부전 동반시 <2000mg/day(소금 <5g)	ADA, Standards of Medical Care in Diabetes-2008
캐나다	Little or no added fat, sugar or salt	CDA, 2008 Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada
일 본	소금 <10g/day 고혈압이나 단백뇨 동반시 <7g/day	JDS, Treatment Guide for Diabetes, 2007
유 럽	소금 <6g/day	EASD, Evidence-based nutritional approaches to the treatment and prevention of diabetes mellitus

국내 지침

기관	권 고 량	출 처
대한당뇨병학회	나트륨 < 4000mg/day(소금 10g) 고혈압, 신장 및 심혈관계합병증 동반시 2000-3000mg/day(소금5-7g)	당뇨병 진료지침 2011 제4판, 대한당뇨병학회, 2011
한국지질동맥경화학회	< 2000mg/day (소금<5g)	이상지질혈증 치료지침 2판, 한국지질동맥경화학회, 2009
한국인영양섭취기준	목표량 2000mg/day (소금<5g)	2010 한국인 영양섭취기준, 한국영양학회, 2010

결론 및 제언

- 소금섭취는 혈압 상승 및 심혈관질환의 위험도와 연관성이 높으므로 섭취 제한이 필요하다.
- 고혈압이나 신장합병증, 심혈관계질환의 합병증을 동반한 경우에는 좀 더 엄격하게 제한한다.
- 국내 근거자료가 부족하므로 당뇨병 환자의 소금 섭취량 추정하기 위한 대단위 규모의 조사가 필요하다.
- 당뇨병 환자의 소금섭취량과 관련된 음식의 종류, 식생활 특성 등을 분석하여 구체적이고 실질적인 식사지침을 제시하는 것이 필요하다.

감사합니다!